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Power Output	Modulation Characteristics	Dynamic Range
Warm-up Time	Modulator Bandwidth	
Channel Selection Time	Transmitter Range	
Carrier Noise Level	Receiver Selectivity	
Sidetone Response	Audio Frequency Response	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Outlines test procedures and methods for use in evaluating the operational performance of receivers, transmitters, and transceivers. Includes checklist and data collection sheets.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105
*Test Operations Procedure 6-2-242 15 June 1981
AD No. A100395

RECEIVER-TRANSMITTER SYSTEM TESTS

1. SCOPE

These procedures outline the particular tests and test methods for use in evaluating the performance and characteristics of general types of receiving and transmitting equipments. They serve as a guide in determining the overall efficiency of such equipments as a function of their design and their recorded performance. Notwithstanding the accuracies, frequencies, and levels stated in this test operations procedure (TOP), the specific equipment requirements stated in the appropriate requirements document must be used.

1.1 Subtests:

1.1.1 Power Output. The objective of the subtest is to measure the test transmitter's output power as a function of the frequency to which it is tuned.

1.1.2 Warm-up Time. The objective of the subtest is to determine whether the transmitter meets the specified time requirements for warm-up prior to operation.

1.1.3 Channel Selection Time. The objective of the subtest is to determine the minimum time required to change from one transmitter operating frequency to another. This subtest should only be conducted if the specifications for the test item indicate the need for evaluating channel selection time.

1.1.4 Carrier Noise Level. The objective of the subtest is to determine the amount of residual noise present on a test transmitter's unmodulated carrier signal.

*This TOP supersedes MTP 6-2-242, 1 September 1967 and MTP 6-2-515, 15 December 1969.

1.1.5 Sidetone Response. The objective of the subtest is to determine the transmission level of sounds over a local path from the transmitter to a receiver at the same station.

1.1.6 Modulation Characteristics. The objective of the subtest is to determine the relationship between the radio frequency (RF) output amplitude and the instantaneous modulation amplitude of the test transmitter.

1.1.7 Modulator Bandwidth. The objective of the subtest is to determine if the test transmitter's modulator has excessive bandwidth that causes sidebands to occur that exceed the channel limits.

1.1.8 Transmitter Range. The objective of the subtest is to determine the effective line-of-sight (LOS) operation for the test transmitter.

1.1.9 Audio Frequency Response. The objective of the subtest is to determine the manner in which the electrical output of the test receiver is dependent on the modulating frequency of the signal.

1.1.10 Dynamic Range. The objective of the subtest is to determine the degree of signal distortion between the test receiver's standard response level and its limiter level.

1.1.11 Selectivity. The objective of the subtest is to determine the ability of the test receiver to discriminate the desired frequency from undesirable frequencies that are within close frequency range of the desired frequency.

1.2 Limitations:

1.2.1 This procedure considers receivers, transmitters, and transceivers under test as major components. The input/output functions of a particular test item are reflected as voltage measurements indicating the respective signal, noise, and distortion levels that are recorded.

1.2.2 This procedure is limited to particular methods for observing the operational performance of test receivers, transmitters, and transceivers; it does not consider testing of the human factors, environmental testing, the maintainability, and the transportability aspects of a particular test item.

1.3 Exclusions. Several specific tests that are generally applied to receivers, transmitters, and transceivers are omitted in this TOP because they are replicated in other TOPs and/or military standards. When a need arises to include such testing in the test plan, the following tests with appropriate references may be used:

a. Transmitter Frequency Accuracy and Stability: TOP 6-2-517.

b. Electrical Power Requirements: TOP 6-2-514.

c. Spurious Emission and Response: TOP 6-2-545 and MIL-STD-449D.

d. Electromagnetic Vulnerability: TOP 6-2-508.

e. Electromagnetic Compatibility and Radio Frequency Interference: MIL-STD-461B.

f. Spectrum Signature: MIL-STD-449D.

g. Radio Receiver Sensitivity (Non-Pulsed): TOP 6-2-544.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities:

ITEM	REQUIREMENT
Communications Test Facility	Used to simulate the tactical configurations in which the test item is designed to function.
Screen Room (Shielded Enclosure)	Used to minimize the effects of electromagnetic interference (EMI) and reflection; 100 dB attenuation of all radiated fields.
Mobile Data Acquisition Facility	Used to monitor the performance of the test item at various measured test sites.
Antenna Measurement Facility	Used to determine antenna patterns of various radiating devices.
Field Ranges	Used for long distance transmission tests and with equipment too large for closed loop testing. Located in an electronically quiet area.

2.2 Instrumentation: All instrumentation used during testing under this procedure will have a current calibration certificate indicating that it meets the requirements outlined in MIL-STD-449D, paragraph 5.1.

2.2.1 The specific instrumentation requirements for a particular test program are dependent on the design of the equipment being tested. The test officer will insure that the accuracy and stability of the measuring instrument shall exceed the accuracy and stability of the equipment undergoing test by at least one order of magnitude.

2.2.2 The appropriate use of automatic test equipment (ATE) should be considered by the test officer when planning for the data collection effort.

In addition, the test officer may consider the following instrumentation and equipment based on the design of the equipment being tested and the specific test procedures to be used:

ITEM	CHARACTERISTICS/ACCURACY (OR AS APPROPRIATE)
Frequency Counter	Maximum frequency to 1 GHz ± 3 parts in 10^7/30 days
RF Signal Generator	Frequency Range: 100 KHz to 1 GHz Modulation: AM and FM Width: Continuously adjustable from zero to 10% of usable frequency range Width Accuracy: ± 2% of max Δ F
Spectrum Analyzer	Frequency range: 100 KHz to 1 GHz Frequency span: Variable from 10 KHz to 1 GHz Calibrator Accuracy: ± 0.2 dB amplitude 0.002% frequency Sensitivity: -105 dBm to 1 GHz with 1 KHz resolution bandwidth Frequency response: ± 1 dB to 1 GHz
Distortion Analyzer	Frequency range: 10 Hz to 110 KHz Residual distortion: 0.002% audio band Oscillator output: From -90 dBm to +27 dBm
Oscilloscope	Bandwidth: dc to 50 MHz at 5 mV/div to 10 mV/div ac coupled 10 Hz or less at all deflection factors (-3 dB) Horizontal accuracy: Within 3% Vertical overshoot: Less than 3% For use as a visual indicator with voltmeter
Audio Oscillator (Function Generator)	Frequency range: 0.001 Hz to 40 MHz Dial accuracy: Within 3% to 4 MHz full scale; within 6% to 40 MHz full scale Frequency stability: 0.05% full scale for 10 minutes; 0.1% full scale for one hour; 0.5% full scale over 24 hours Sine wave harmonic distortion: 0.15%

ITEM	CHARACTERISTICS/ACCURACY (OR AS APPROPRIATE)
Dummy Load/Terminating Resistor	0.1 watt to 50 KW ± 5% resistance
Strip Chart Recorder	Channel span: one analog channel Nonlinearity: ± 0.5% full-scale reading
Frequency Selective Wattmeter	± 5% full-scale reading (range comparable to equipment under test) Insertion SWR: Less than 1.05:1
On-line Wattmeter	± 3% full-scale reading (range comparable to equipment under test)
Frequency Selective Voltmeter (Field Intensity Meter)	Frequency range: 1.5 to 400 MHz Sensitivity: 0.5 microvolts Selectivity: 2.1 KHz at -6 dB
True RMS Voltmeter (Multimeter)	DC voltage accuracy: ± .25% of reading AC voltage accuracy: ± .75% of reading AC current accuracy: ± 1.5% of reading Resistance accuracy: 200 Ω range; ± 0.3% of reading; 20 M Ω range; ± 0.25% of reading; other ranges ± 0.25% of reading
Receiver Monitors	Frequency range: 1.5 to 400 MHz (AM/SSB/FM) Sensitivity: 0.5 microvolts for 10 dB (SSB) Selectivity: 2.1 KHz minimum at -6 dB; 5 KHz maximum at -60 dB
Power Meter Frequency Synthesizer (Audio Frequency)	± 2% Frequency range: 30 to 20,000 Hz
Camera	Shutter speed 1/25 sec. to 1/12,000 sec. with strobe synchronization Focus: beam splitter Resolution: 56 lines/mm

ITEM	CHARACTERISTICS/ACCURACY (OR AS APPROPRIATE)
Tunable Antennas	
Transit	
Aiming Stakes	
Turntable	
Topographical Maps	
Meteorological Equipment	Field type: Barometer, hygrometer, thermometer

3. PREPARATION FOR TEST

3.1 Planning. The test officer must assure himself that the test plan will sufficiently exercise the test item to accomplish the reasons for undertaking the test. For development tests (DT), the Independent Evaluation Plan (IEP) and the Test Design Plan (TDP) will usually outline the particular requirements to be included in the test plan. The assigned test officer will activate a project notebook for each test item, recording in it pertinent descriptive and technical information. The project notebook provides a narrative discussion of test conduct and results and is kept current for the duration of the test program. In addition, test planning encompasses a consideration of the potential foreign threat factors that will permit a realistic evaluation of the test item in a threat environment. Complete test planning requires that the test officer:

a. Prepare a test operations checklist using appendix A as a guide.

b. Incorporate complete safety aspects within the preparations for the test.

c. Brief test personnel on all aspects of the test program to include the purpose of the test and the precision requirements during test conduct.

d. Provide sufficient copies of operating instructions to all test personnel.

3.2 Facilities. Preparation of the test facilities to be used for the conduct of receiver, transmitter, and transceiver testing should include:

a. Adequate lead time for scheduling the test facilities that are to be involved.

b. Preparation of laboratory benches and floor space.

c. Adequate power distribution.

d. Assembly of tools, operating instructions, loads, and equipment handling devices.

e. Ambient environmental conditions.

f. The need, insofar as is practicable, to conduct all tests within a screen room to minimize the impact of an adverse electromagnetic environment.

3.3 Test Item. In his preparations for test conduct, the test officer will insure that:

a. A record of the test item nomenclature, its technical characteristics, its manufacturer, and its performance parameters are entered into the project notebook.

b. The test item is photographed from several perspectives to provide a nonambiguous visual identification and description of the test item.

c. The test item and all of its associated components are inspected for damage, deterioration, and obvious manufacturing defects.

d. The test item is in proper operating condition.

3.4 Instrumentation. In his preparations for test conduct, the test officer will insure that:

a. All test equipment and other instrumentation is scheduled and readily available for use during test conduct.

b. All test equipment is calibrated prior to the scheduled test start date and that calibration standards equal or exceed the standards stipulated in paragraph 2.2.1 above.

c. The signal generators used during testing have a source impedance equal to the impedance of the receiver-transmitter unit under test.

3.5 Equipment Set-up. In his preparations for test conduct, the test officer will determine, from the specified parameters for test conduct, whether closed loop and/or open field measurements are appropriate to adequately exercise the test item. Figures 1 and 2 on the following page indicate the general equipment configurations for closed system and open field measurements.

4. TEST CONTROLS

This paragraph describes the necessary controls over test conduct to insure that testing is complete and technically accurate. Appendix C is a general discussion of the standard test conditions that apply to the conduct of the various performance tests delineated under paragraph 5 below.

CLOSED-LOOP MEASUREMENTS

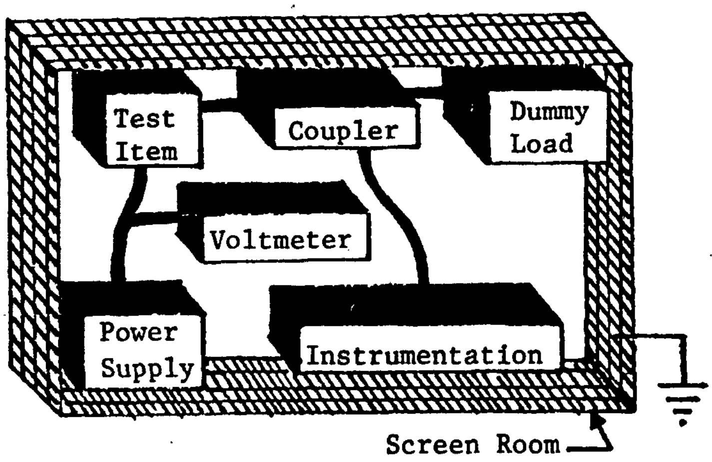


Figure 1 - Equipment Set-up

OPEN FIELD MEASUREMENTS

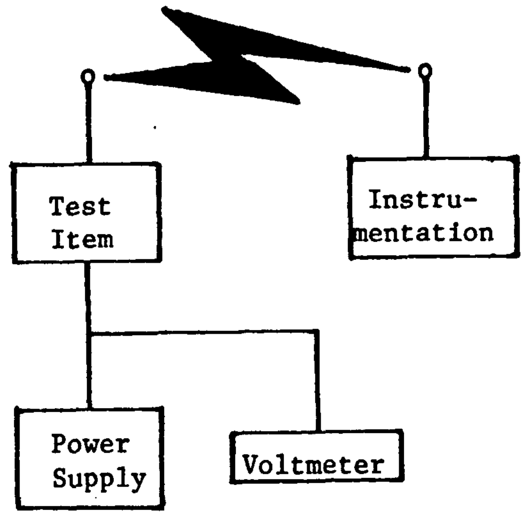


Figure 2 - Equipment Set-up

4.1 Facilities:

a. The test facility's ambient temperature is indicated in appendix C, paragraph 2.1, and should not vary more than 15°C.

b. Line voltages used to power the test item and associated instrumentation should not vary more than five percent from the mean.

c. Record a measurement of background interference prior to test start. This recording can be used at a later time to distinguish local environmental conditions from the special conditions generated by the test item.

4.2 Test Item:

a. The tuning procedures used for all test items will follow the instructions contained in a technical manual or manufacturer's operational instructions.

b. Except as directed by test procedures, the test item will not be moved, adjusted, or calibrated while comparative and reproducibility tests are in progress.

c. Antennas and dummy loads will be kept consistent throughout the conduct of comparative and reproducibility testing.

4.3 Instrumentation:

a. Applicable instrumentation will satisfy the standards for accuracy and stability as outlined in paragraph 2.2.1 above.

b. Instrumentation will be calibrated prior to test conduct.

c. The same instrumentation will be used throughout a particular subtest.

4.4 Standard Test Frequencies. The tests outlined in this procedure will be performed at the standard test frequencies described in MIL-STD-449D, paragraph 3.20.1.

4.5 Control Settings: The control settings for the test item during test conduct are shown in tables 1 and 2. For receivers, adjust the audio gain control for the rated audio output at the sensitivity level. For all tests, use the standard test frequencies referred to in paragraph 4.4 above. In a case where the control setting is inapplicable for a given step, e.g., AFC on, when the test item has no AFC control, the setting may be ignored.

RECEIVER CONTROL SETTINGS

CONTROL	TYPE OF TEST		
	Selectivity	Audio Frequency Response	Dynamic Range
RF Gain	Max	Max	(1)
Selectivity	(1)	Max	Max
AGC	(2)	(2)	Off
AFC	Off	On	On
Limiter Switch	Off	Off	Off
Antenna Trimmer	Peak for Max Response	Peak for Max Response	Peak for Max Response

(1) Perform test at minimum, average, and maximum settings.
(2) Perform test at medium or fast response.

Table No. 1

4.6 Impedance Matching Requirements. Signal generators used during testing will have a source impedance equal to that of the receiver, transmitter, or transceiver undergoing test.

4.7 Interference Free Measurements. Where practical, testing will be conducted in a screen room to minimize the impact of external electromagnetic factors. Where it is the specific purpose of testing to ascertain the impact of the external electromagnetic environment, e.g., transmitter range testing, this test control would not apply.

4.8 Standard Modulation Test Frequencies:

a. For single sideband (SSB) transmitters, use 400 and 2,500 Hz. Use 2,500 Hz for single tone tests.

b. For amplitude/frequency modulated (AM/FM) transmitters, use 1,000 Hz.

TRANSMITTER CONTROL SETTINGS

TYPE OF TEST	CONTROLS	
	Frequency	Power Output
Power Output	(1)	Hi & Lo
Warm-up	(2)	Hi
Channel Selection Time	(1)	Hi
Carrier Noise	(2)	Hi & Lo
Sidetone Response	(2)	Hi
Modulator Bandwidth	(2)	Hi
Modulation Characteristics	(2)	Hi

(1) Perform test at sufficient tuned frequencies to adequately cover the frequency range.
(2) Perform test at standard test frequencies (see paragraph 4.4.1 above).

Table No. 2

4.9 Standard Modulation Levels:

a. For SSB transmitters, use an input to provide equivalent rated peak envelope power (PEP) where:

(1) PEP is the ratio of the amplitudes for a two-tone power level single-tone power level respectively; and

(2) Rated PEP is defined as the power resulting from a transmitter load from two equal tones that is 25 decibels (dB) below the amplitude of the tones.

b. For AM transmitters, use an input necessary to produce an output signal at 90 per cent of modulation unmodulated carrier (AO emission).

c. For FM transmitters, use an input necessary to produce an output signal at 90 per cent of the rated deviation using unmodulated carrier (FO emission).

d. Modulation for Receiver Testing:

(1) The signal generator modulation used in receiver testing is dependent on the standard response of the test receiver (see MIL-STD-449D, paragraph 3.20).

(2) For SSB receivers, simulate standard modulation using an unmodulated carrier 1,000 Hz above and below the desired frequency setting.

(3) For AM receivers, standard modulation is 30 per cent at 400 Hz.

(4) For FM receivers, standard modulation is 30 per cent of rated deviation at 1,000 Hz.

4.10 Standard Audio Response:

a. For SSB and AM receivers, a 10 dB signal-plus-noise to noise ratio constitutes the standard audio response (see MIL-STD 449D, paragraph 3.20 and 5.4.2.2).

b. For FM receivers, a 20 dB of quieting[1] under unmodulated conditions constitutes the standard audio response.

5. PERFORMANCE TESTS

5.1 Method.

5.1.1 Power Output:

a. AM/FM Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in figure 3. The degree of coupling provided by the signal sampler should minimize inputs to the field intensity meter to a few volts.

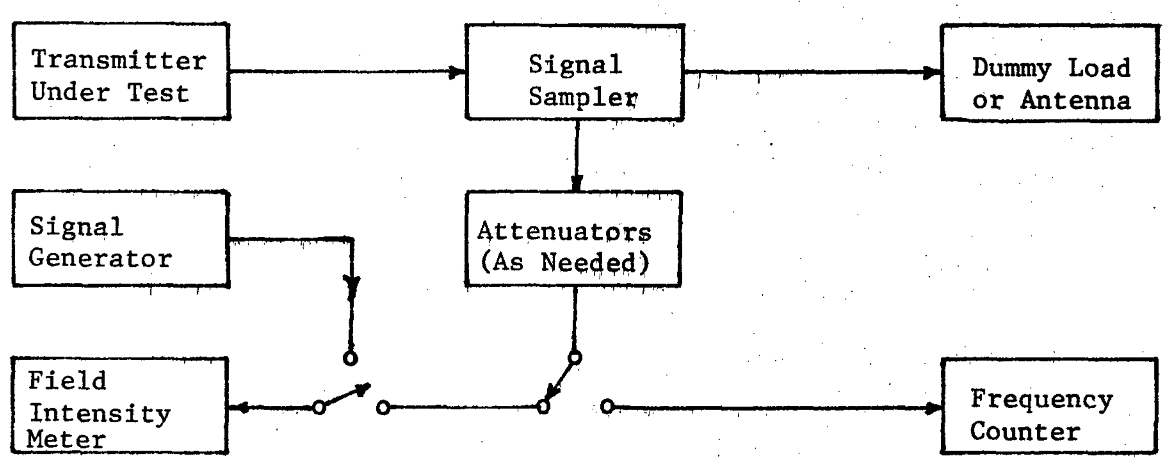


Figure 3 - Block Diagram of AM/FM Power Output Measurements

1/ Quieting is defined as the decrease in noise voltage at the output of an FM receiver in the presence of an unmodulated carrier. See R.F. Graf, Modern Dictionary of Electronics, H.W. Sams & Co., Inc., 1977.

(2) Use an unmodulated carrier type of emission (AO/FO) for transmitter modulation.

(3) Tune the test transmitter to a standard test frequency.

(4) Tune the field intensity meter to the transmitter carrier frequency. Adjust the attenuator and/or the field intensity meter gain control to provide a convenient reference reading on the field intensity meter.

(5) With the signal generator tuned to the transmitter carrier frequency, substitute that signal at the input to the field intensity meter. Adjust the signal generator until the reference reading is again produced on the field intensity meter. Record the signal generator output level and frequency.

(6) Repeat steps (4) and (5) for those test frequencies required to adequately cover the test transmitter's frequency range.

b. Single Sideband (SSB) Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in figure 4.

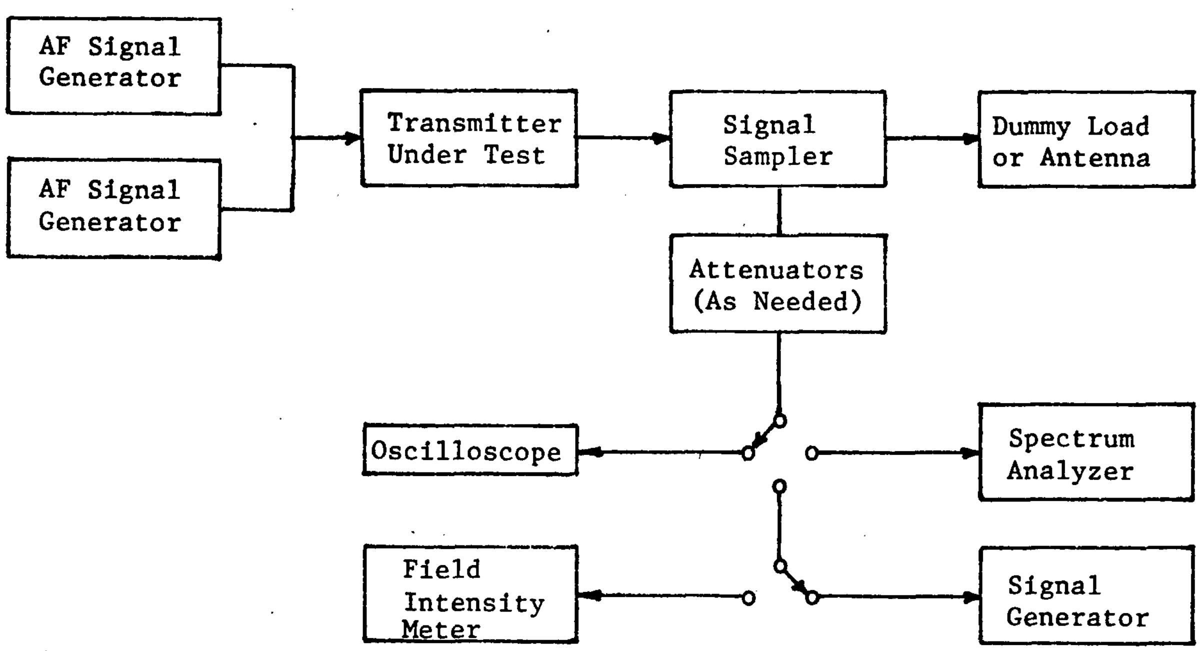


Figure 4 - Block Diagram of SSB Power Output Measurements

(2) Feed a 400 Hz tone into the test transmitter with its carrier suppressed in a manner that the resulting power output approximates the designed continuous wave (CW) level of the transmitter.

(3) Apply 400 Hz and 2,500 Hz tones to the transmitter. Adjust for equal amplitude in the test transmitter's output. Holding the equal amplitude output condition, increase the tone levels until the transmitter emits maximum power output. Record the amplitude of the waveform as reflected on the oscilloscope.

(4) Remove the 2,500 Hz tone; record the amplitude of the 400 Hz waveform as reflected on the oscilloscope.

(5) Repeat steps (2), (3), and (4) for those test frequencies required to adequately cover the test transmitter's frequency range.

5.1.2 Warm-up Time: (This test should follow the power output subtest).

a. Allow the transmitter to reach an ambient temperature after completion of the power output subtest.

b. Turn the transmitter on and record the time at which it was turned on.

c. Tune the transmitter to a standard test frequency and re-establish conditions of maximum power output.

d. Record the time at which the transmitter attained its maximum power output.

5.1.3 Channel Selection Time:

a. Arrange the equipment for test in a manner similar to that shown in figure 5.

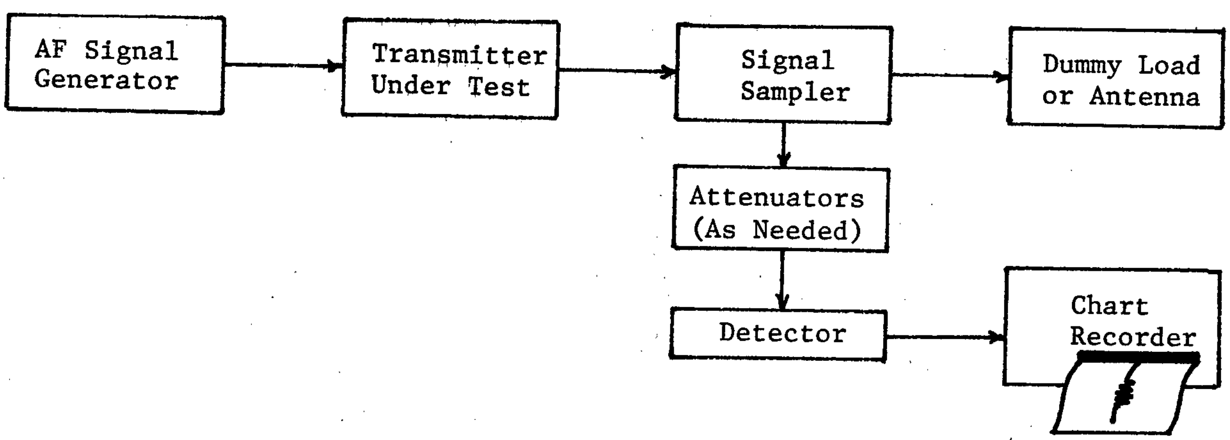


Figure 5 - Block Diagram of Channel Selection Time Measurements

b. Apply standard input modulation to the transmitter.

c. Start with the lowest frequency setting and record the detected output waveform as a function of time as the transmitter is tuned to successively higher frequency settings.

d. From the data collected, select the two frequency settings which required the longest tuning cycle.

e. Repeat steps b and c using only those two frequencies at which the longest tuning cycle was observed and record the time as the test item's maximum channel selection time.

5.1.4 Carrier Noise Level:

a. Arrange the equipment for test, AM/FM, and SSB transmitters in a manner similar to that shown in figure 6.

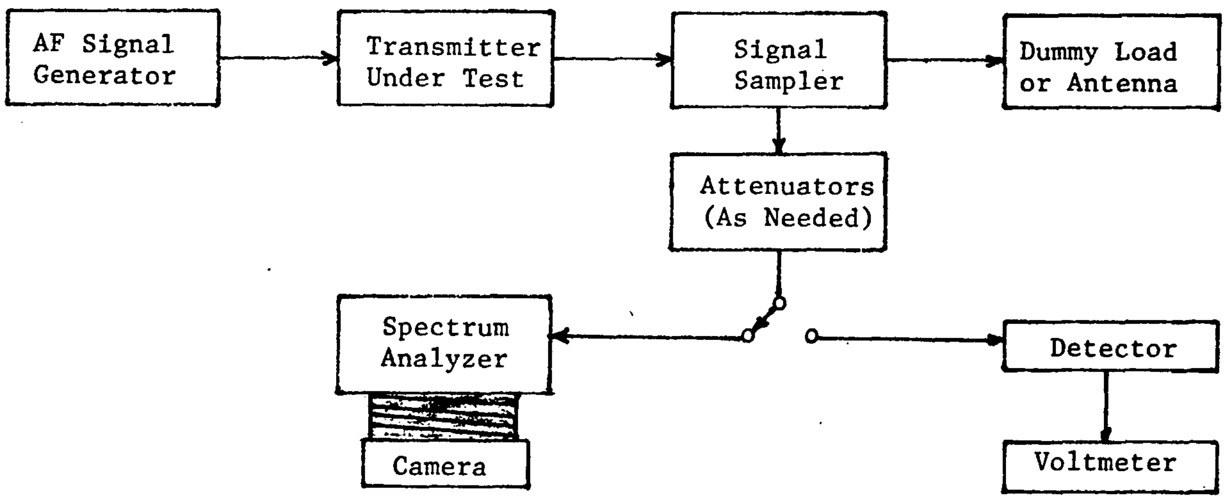


Figure 6 - Block Diagram of Carrier Noise Level Measurements

b. Adjust the signal sampler for adequate voltage to operate the spectrum analyzer.

c. Adjust the spectrum analyzer to permit a visual presentation of all carrier noise components; adjust the sweep rate for maximum resolution.

d. Set the exposure time on the camera to include two sweeps. Record the test item's carrier level and all instrumentation settings.

e. In the case of AM/FM transmitters undergoing test, switch the output from the spectrum analyzer to the detector.

f. Determine the detector noise level by turning the test item off. Turn the test item on and apply standard modulation. Measure the output level of the detector.

g. Remove the audio input signal and again record the detector output level.

5.1.5 Sidetone Response:

a. Arrange the equipment for test in a manner similar to that shown in figure 7.

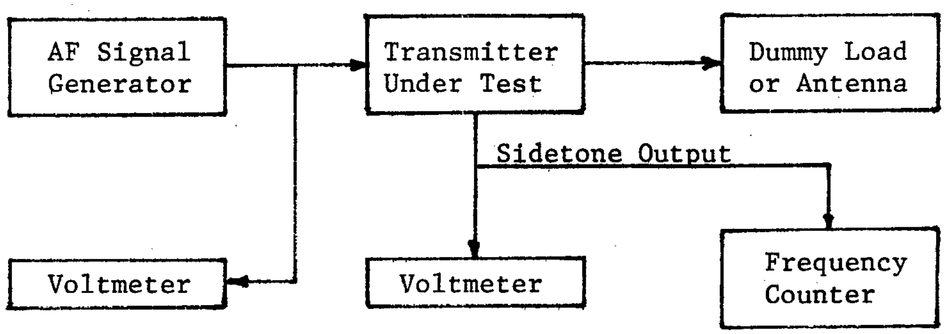


Figure 7 - Block Diagram of Sidetone Response Measurements

b. Adjust the signal generator and test item for a rated sidetone output level, a rated power output, and for standard modulation.

c. Maintain the audio input level and sweep through the audio frequency band, from 350 to 2,500 Hz, in incremental steps. Record both the audio frequency and the sidetone output level at each step.

5.1.6 Modulation Characteristics:

a. AM/FM Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in figure 8.

(2) Determine the distortion level of the demodulator.

(3) Set the signal generator at 1,000 Hz; minimize the output control and connect the generator to the modulator input. Slowly increase the generator's output while observing the modulation monitor and distortion analyzer. Record sufficient values of percentage modulation and distortion to permit a graphical portrayal of the functions.

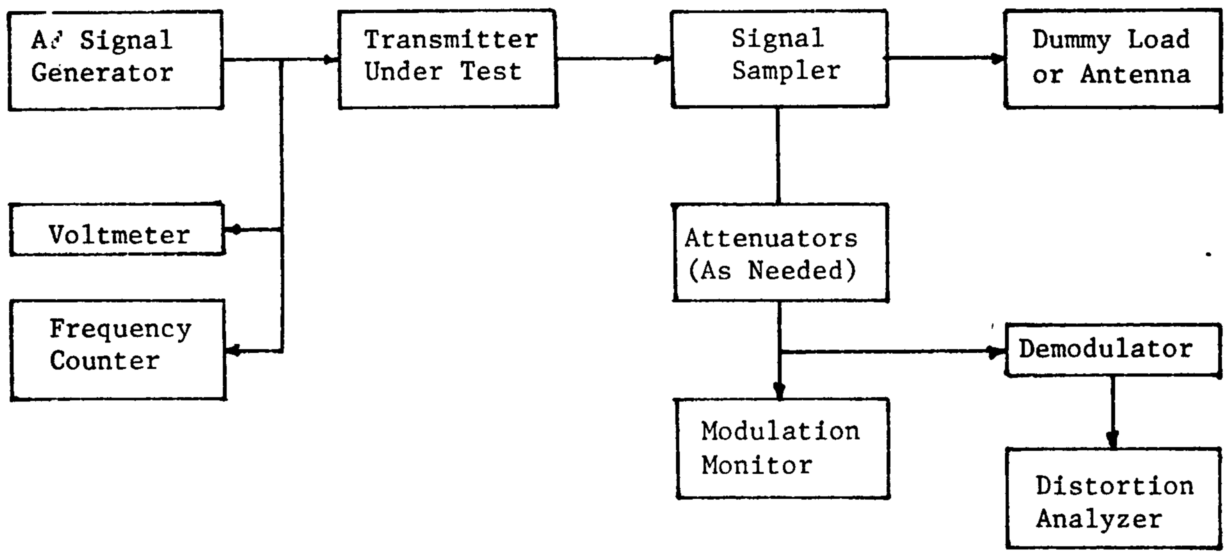


Figure 8 - Block Diagram of Modulation Characteristics Measurements (AM/FM)

b. SSB Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in Figure 9.

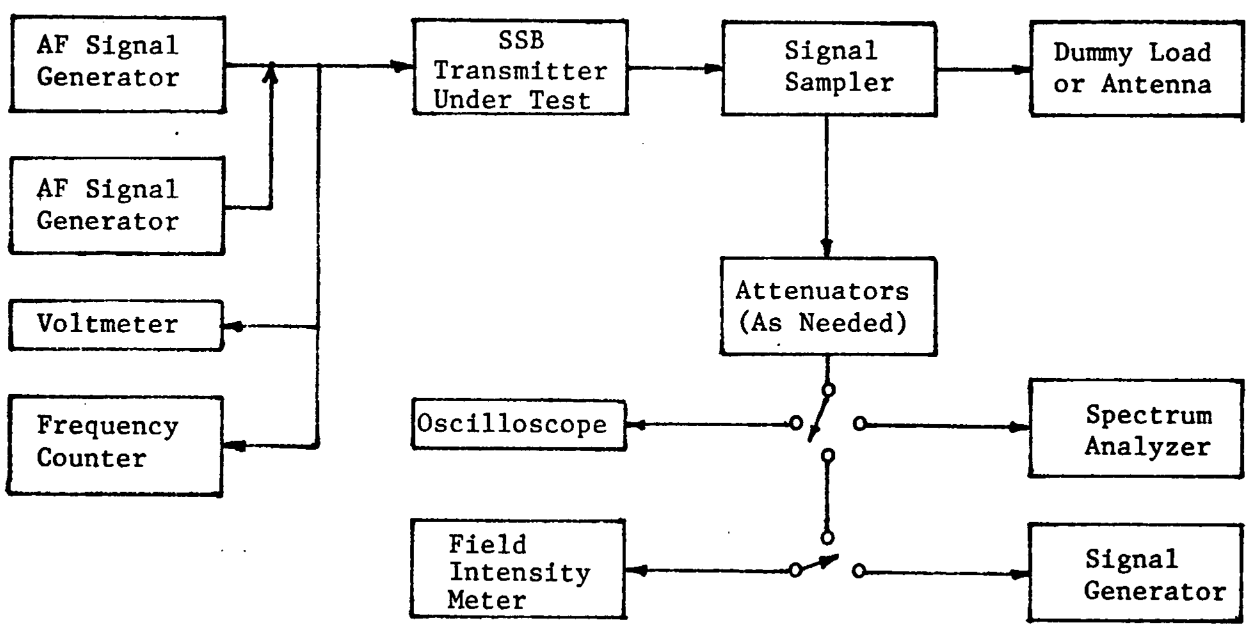


Figure 9 - Block Diagram of Modulation Characteristics Measurement (SSB)

(2) Adjust the signal sampler for sufficient voltage to drive the field intensity meter.

(3) Inject a standard two-tone test frequency with the power output control set in the high position. Adjust the tones so that their amplitudes are equal at the test item's output.

(4) Adjust the transmitter for rated peak-envelope power (PEP). Record the PEP and the level of distortion as taken from the spectrum analyzer.

(5) Repeat steps (3) and (4) for a sufficient number of test frequencies to permit a graphical portrayal of audio input voltage as a function of radio frequency (RF) output.

5.1.7 Modulator Bandwidth:

a. AM/FM Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in figure 8, page 16.

(2) Adjust the signal generator and test transmitter controls for 30 per cent modulation at a standard modulation frequency.

(3) Vary the generator's frequency over a range from 200 Hz to 10 KHz and observe the modulation monitor.

(4) Locate the point of maximum modulation percentage, usually in the vicinity of 1,000 Hz.

(5) At the point of maximum modulation percentage keep the signal generator tuned to its frequency and readjust the generator's output control for 30 per cent modulation. Record the frequency and the generator's output level.

(6) Increase the signal generator's output by one decibel (1 dB).

(7) Increase the signal generator frequency until the percentage of modulation drops to 30 per cent. Record the frequency.

(8) Drop the signal generator's frequency until the percentage of modulation drops to 30 per cent. Record the frequency.

(9) Repeat steps (6), (7), and (8) for audio increases of three, six, 12, 20, 30 and 40 decibels (dB).

b. SSB Transmitters:

(1) Arrange the equipment for test in a manner similar to that shown in figure 9, page 16.

(2) Adjust the signal sampler to provide sufficient voltage to all instrumentation.

(3) To achieve a rated continuous wave (CW) power output, modulate the test transmitter with a fixed frequency tone (2,500 Hz).

(4) Obtain a frequency response from the test item by modulating the transmitter with a second audio tone signal approximately 10 dB below the fixed frequency tone.

(5) Measure the modulator response on the spectrum analyzer and record that response by means of a multiple exposure photograph of the display.

5.1.8 Transmitter Range:

5.1.8.1 General:

a. The concept for testing considers the operation of a test transmitter from a fixed central site and the measurement of its radio frequency (rf) field intensity using a mobile data acquisition facility involving successive moves to more distant measured test sites along pre-surveyed lines of transmission.

b. The transmitter range test is a linear determination of the line-of-sight (LOS) distance over which a test transmitter can effectively maintain communications. Scoring the effectivity of voice communications is discussed in TOP 6-2-508, appendix D.

c. Select transmission paths in all quandrants and over varied terrain features. The surveys of the measured test sites on each transmission path should reflect:

(1) The azimuth and distance from the site to the central site.

(2) The elevation angle used, if any.

(3) A path profile reflecting terrain features along the transmission path.

d. Range tests necessarily involve an operational type of environment and, depending upon the type of transmitter being tested, considerable distances between the test transmitter and the mobile data acquisition facility.

e. For small, low-powered portable transmitters, it may be desirable to retain the mobile data acquisition facility at the central site and move the test item to successively more distant locations. Test emissions from portable transmitters should be made with the operator in various positions, e.g., operator lying prone facing the monitor; lying prone facing away; kneeling facing; kneeling facing away; standing facing; and standing facing away.

5.1.8.2 Test Procedures. Commence range tests at a central test site or facility to insure the operational capabilities of the test item and instrumentation. Normally, the mobile data acquisition facility will then move to successively more distant measured test sites. The following steps are appropriate for the central and measured test sites:

a. Central Site:

(1) A typical equipment arrangement for range testing FM/LOS transmitters is shown in figure 10.

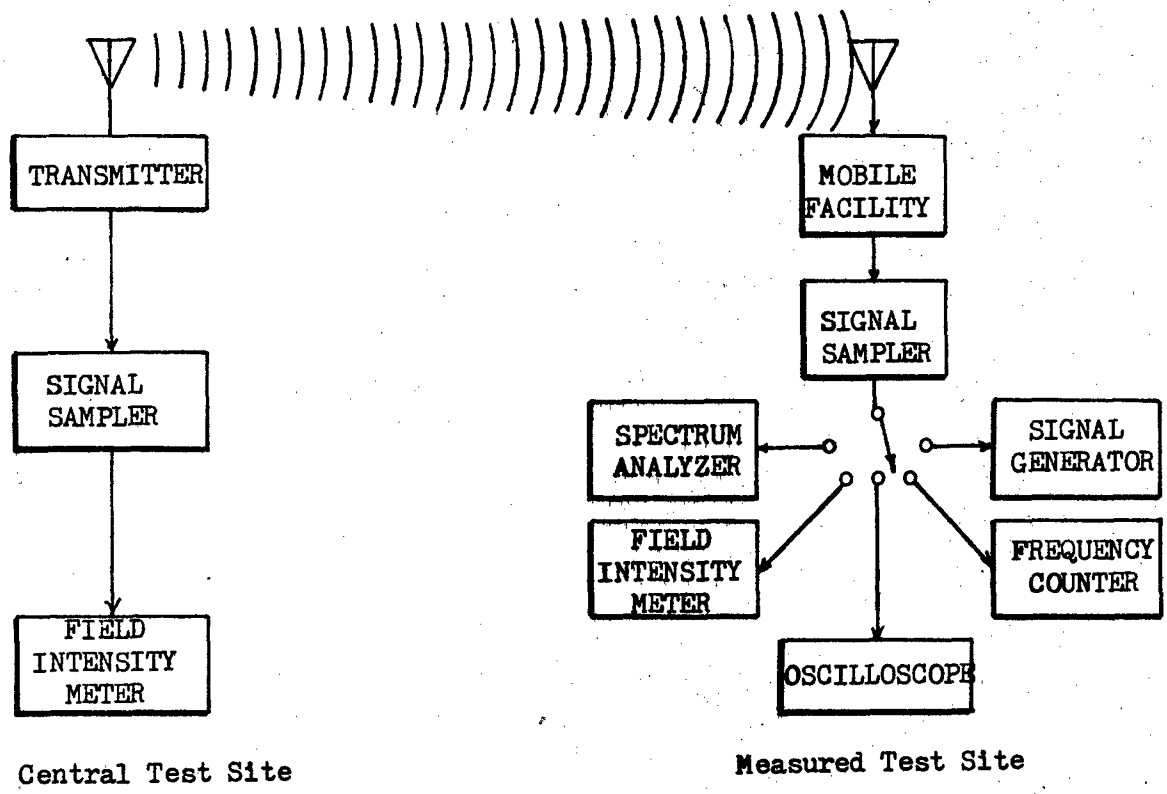


Figure 10. Block Diagram for Transmitter Range Measurements

(2) Operate the test transmitter using the instructions contained in the operator's manual or provided by the manufacturer.

(3) Use low power to align the test transmitter with the monitoring equipment of the mobile data acquisition facility positioned initially at the central test site.

(4) Tune the test transmitter to a standard test frequency.

(5) Record the frequency in MHz, the signal-to-noise (s/n) ratio in dB, and the power output of the transmitter in dBm per watts (dBm/W).

(6) Repeat steps (4) and (5) for each of the transmitter's tuning bands.

b. Measured Test Site:

(1) After completing alignment and checkout procedures at the central site, move the mobile data acquisition facility to the first in a series of predetermined measured test sites along a specified LOS transmission path.

(2) Measure and record the atmospheric pressure, the temperature, and the humidity at both the central and measured test sites.

(3) When the mobile data acquisition facility is in position and prepared to receive the transmitter's signal, using high power, transmit a standard test frequency in each of the test transmitter's tunable bands. Record each frequency used; measure and record the field intensity at both the central site and the measured test site of each signal used on each frequency.

(4) Turn the transmitter off. Measure and record the ambient radio frequency (rf) noise at the measured test site at each test frequency used.

(5) Repeat steps (2) through (4) above during the hours of darkness.

(6) Repeat steps (2) through (5) at each successively more distant measured test site along the transmission path until:

- The field intensity of the emitted signal falls below a predetermined minimum value; or
- The rf s/n ratio falls below a predetermined minimum value; or
- A predetermined maximum acceptable range is achieved.

(7) Repeat steps (2) through (6) for each LOS transmission path used.

5.1.9 Audio Frequency Response:

a. General:

(1) Arrange the equipment for test in a manner similar to that shown in figure 11.

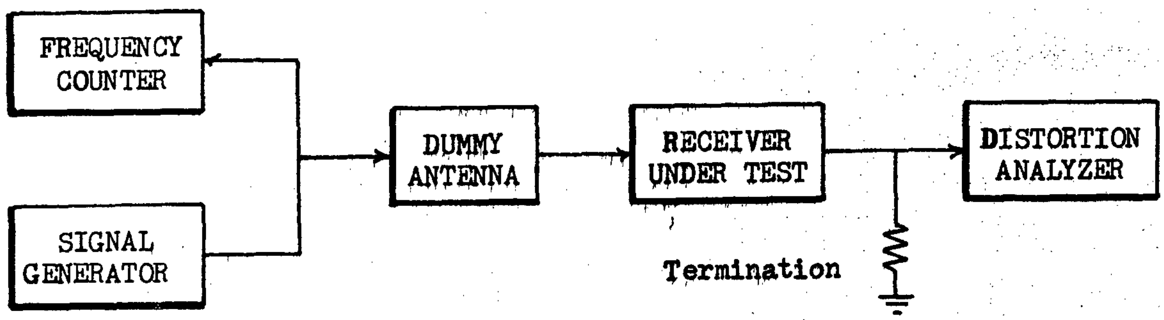


Figure 11.
Block Diagram for Audio Frequency Response and Dynamic Range Measurements

(2) The test receiver's audio gain control will be set for the rated power output at the modulating frequency of peak response or, if an audio overload is apparent, at a recorded reduced setting.

b. AM/FM Receivers:

(1) Within the linear portion of the test receiver's dynamic range, set the level of the generator's output signal to obtain an intermediate value between the test receiver's sensitivity and limiting levels.

(2) Maintain the modulation level at 30 per cent. Adjust the modulating frequency for maximum receiver output.

(3) Reduce the modulating frequency, keeping the modulation percentage constant, until the test receiver's output drops one dB and record that frequency.

(4) Repeat steps (1) through (3) for output drops of three, six, 10, 20, and 30 dB.

c. SSB Receivers:

(1) Within the linear portion of the test receiver's dynamic range, set the level of the generator's input signal to obtain an intermediate value between the test receiver's sensitivity and limiting levels.

(2) Tune the signal generator for a maximum output indication on the frequency meter and record the frequency as a reference frequency.

(3) Adjust the signal generator above the reference frequency until the receiver output drops one dB and record that frequency.

(4) Adjust the signal generator below the reference frequency until the receiver output drops one dB and record that frequency.

(5) Repeat steps (1) through (4) for output drops of three, six, 10, 20, and 30 dB.

5.1.10 Dynamic Range. The dynamic range of a receiver is a measure of the difference between its overload level and its minimum acceptable signal level. Depending on the type of receiver to be tested, i.e., AM, FM, or SSB, the procedures outlined in subsequent subparagraphs are appropriate to determine the dynamic range characteristics of a receiver.

a. Generally, the following steps apply to all types of receivers undergoing dynamic range testing:

(1) Arrange the equipment for test in a manner similar to that shown in figure 11, page 21.

(2) Use at least three test frequencies in the low, mid, and high range of the receiver during test conduct.

(3) Adjust the audio gain control for the rated audio output power at the sensitivity level.

(4) Set the selectivity control at maximum.

(5) Set the radio frequency (rf) control at maximum.

(6) Move the limiter switch to the OFF position.

(7) Move the squelch control to the OFF or DISABLED position.

(8) Move the automatic frequency control (AFC) to the ON position.

(9) Move the automatic gain control (AGC) to the DISABLED or OFF position.

(10) Peak the antenna trimmer for a maximum reading on the indicator.

b. AM Receivers:

(1) Tune the receiver and the signal generator to the lowest standard test frequency.

(2) Set the signal generator modulation to 30 per cent at 500 Hz.

(3) Adjust the generator output (receiver input) until the distortion analyzer shows a standard response at the minimum generator output level (see paragraph 4.9, above). Record the frequency, in Hz, and the generator output level, in dBm. This is the minimum acceptable signal level.

(4) Raise the generator output level six dB and record both the output signal level and the amount of distortion indicated on the distortion analyzer.

(5) Repeat step (4), above, output increments of 6 dB until a change in the receiver input level produces no significant change on the distortion analyzer. This is the overload level.

c. FM Receivers:

(1) Refer to TOP 6-2-544, paragraph 5.5, on quieting sensitivity to determine the minimum acceptable signal level that results in 20 dB quieting.[2]

(2) Using the same signal generator output, in dBm, as that used in step (1) above to determine the minimum acceptable signal level, modulate the signal with a 1,000 Hz tone at a maximum standard deviation of 75 KHz.

(3) Raise the modulated signal generator output six dB and record both the output signal level and the amount of distortion indicated on the distortion analyzer.

(4) Repeat step (3) above, using output increments of six dB until a change in the receiver input level produces no significant change on the distortion analyzer. This is the overload level.

d. SSB Receivers:

(1) Test in both the upper and lower sideband modes of the test item.

(2) Tune the unmodulated signal generator to a frequency 1,000 Hz above or below the tuned frequency of the test receiver.

(3) Adjust the generator output (receiver input) until the distortion analyzer shows a standard response at the minimum generator output level (see paragraph 4.9 above). Record the frequency, in Hz, and the generator output level, in dBm. This is the minimum acceptable signal level.

(4) Repeat steps (1) through (3) above for each channel setting along the receiver's tuning range.

(5) Raise the generator output level six dB and record both the output signal level and the amount of distortion indicated on the distortion analyzer.

2/ Ibid., page 11.

(6) Repeat step (5) above, using output increments of six dB until a change in the receiver input level produces no significant change on the distortion analyzer. This is the overload level.

5.1.11 Selectivity:

a. General:

(1) Receiver selectivity, an indication of the receiver's capability to discriminate off-channel emissions, is a measure of the test receiver's bandpass characteristics.

(2) Arrange the equipment for test in a manner similar to that shown in figure 11, page 21.

b. Depending on the type of receiver to be tested, i.e., AM, FM, or SSB, follow the procedures outlined for dynamic range testing outlined in paragraph 5.1.10a and b, c, or d to determine the minimum acceptable signal level.

c. Increase the signal generator output three dB. Slowly tune the generator below the receiver's tune frequency until the standard response is re-established. Record the input frequency and power output.

d. Repeat steps b and c at signal levels that are six, 12, 20, 40, 60, and 80 dB above the recordings taken in step b above.

5.2 Data Required.

5.2.1 Power Output:

a. AM/FM Transmitters:

(1) The frequency, in KHz/MHz, to which the transmitter is tuned.

(2) The signal generator output level in decibels per milliwatt (dBm).

(3) The signal sampler coupling in decibels (dB).

(4) The losses, in dB, resulting from the use of attenuators.

(5) Cable losses in dB.

b. SSB Transmitters:

(1) The frequency, in KHz/MHz, to which the transmitter is tuned.

(2) The amplitude, in volts, of each of the two-tone waveforms used.

(3) The amplitude, in volts, of the single-tone waveform.

(4) The level of continuous wave (CW) power, in dBm, as read from field intensity meter.

(5) The signal sampler coupling in dB.

(6) The losses, in dB, resulting from the use of attenuators.

(7) Cable losses in dB.

5.2.2 Warm-up Time:

a. The ambient temperature in degrees Celsius (C°).

b. The frequency, in KHz/MHz, to which the transmitter is tuned.

c. Time for warm-up in minutes and seconds.

5.2.3 Channel Selection Time:

a. The frequency, in KHz/MHz, to which the transmitter is tuned.

b. The time in minutes and seconds to tune the transmitter to a progressively higher test frequency.

5.2.4 Carrier Noise Level:

a. A photograph of the calibrated spectrum analyzer display.

b. The frequency, in KHz/MHz, to which the transmitter is tuned.

c. In the case of AM/FM transmitters, a record of the detector readings for both modulated and unmodulated carrier inputs will be maintained.

5.2.5 Sidetone Response:

a. The audio frequency in Hz.

b. The audio input level in volts.

c. The audio output level in volts.

5.2.6 Modulation Characteristics:

a. AM/FM Transmitters:

(1) The audio input level in volts.

(2) The percentage of modulation.

(3) The percentage of distortion.

b. SSB Transmitters:

(1) The audio input level in volts.

(2) A photograph of the calibrated spectrum analyzer display.

(3) The peak-envelope power (PEP) that is transmitted in watts.

5.2.7 Modulator Bandwidth:

a. AM/FM Transmitters:

(1) The input audio level in volts.

(2) Frequency of maximum response.

(3) Input audio voltage and frequencies for audio increases of three, six, 12, 20, 30, and 40 dB.

b. SSB Transmitters:

(1) The input audio level in volts.

(2) Frequency of maximum response.

(3) A photograph of the calibrated spectrum analyzer display.

5.2.8 Transmitter Range:

a. The frequency to which the transmitter is tuned.

b. For AM/FM transmitters, the signal generator output level in dBm.

c. For SSB transmitters, the amplitude in volts of each of the two-tone waveforms used.

d. For SSB trasnmitters, the level of continuous wave (CW) power, in dBm, as read from the field intensity meter.

e. The ambient radio frequency (RF) noise on each test frequency used.

f. Survey and signal path to the measured test sites used.

g. Meteorological Data:

(1) Temperature.

(2) Humidity.

(3) Air Pressure.

(4) Climatic Conditions.

5.2.9 Audio Frequency Response:

a. The radio frequency (rf) input signal level in volts.

b. The modulation frequencies at which the receiver output levels dropped by three, six, 10, 20, and 30 dB below the test item's rated level.

5.2.10 Dynamic Range:

a. The test frequency used.

b. The signal generator outputs in dBm.

c. The amount of distortion recorded in the output signal.

5.2.11 Selectivity:

a. The signal generator's input level, in dBm, to obtain a standard audio response.

b. The input levels and frequencies used for signal levels three, six, 12, 20, 40, 60 and 80 dB above those used to obtain the standard audio response.

6. DATA REDUCTION AND PRESENTATION

6.1. Data Reduction: A thorough error analysis of each measurement is beyond the scope of this document. Further, the desired level of precision for these tests does not warrant a highly exhaustive treatment. If required, appropriate error equations may be found in the National Bureau of Standards Document NBSIR 73-333, Test Procedures Handbook.

6.1.1 Power Output:

a. AM/FM Transmitters:

(1) Adjust the power level of the signal generator to correct for the line losses occurring along the signal path.

(2) Convert the test transmitter's power output from dBm to watts.

b. SSB Transmitters:

(1) Adjust the single-tone amplitude level to correct for the line losses occurring along the signal path.

(2) Compute peak-envelope power (PEP) using the formula:

$$\left[\frac{\text{Two-Tone Envelope Amplitude (Volts)}}{\text{Single-Tone Envelope Amplitude (Volts)}}\right]^2 - \text{PEP (Watts)}$$

6.1.2 Warm-up Time: Compute the time required for the test transmitter to attain its maximum power output after beginning the tuning procedure while the transmitter was at an ambient temperature.

6.1.3 Channel Selection Time: Reduce the chart recording, the raw data reflecting the output waveform as a function of time at a particular frequency/channel setting, to a tabular format indicating the elapsed time to move from the initial channel setting to the next higher setting.

6.1.4 Carrier Noise Level:

a. Reduce the carrier noise level to determine the difference, in dB, between the standard modulated transmitter output from the unmodulated output.

b. Provide a listing of the control settings for the instrumentation used to accompany the photograph of the spectrum analyzer's display.

6.1.5 Sidetone Response: Reduce test data into a tabular format reflecting the audio frequency and the audio input and output levels. Prepare a graphical format to show the sidetone output level as a function of the audio frequencies used.

6.1.6 Modulation Characteristics: For AM/FM transmitters, reduce test data into tabular and graphical formats reflecting the percentages of modulation and distortion as a function of the audio input voltages. For SSB transmitters, the PEP and percentage of rated PEP should be shown as a function of the input voltages.

6.1.7 Modulator Bandwidth: Reduce test data into tabular and graphical formats reflecting the test item's relative response at the upper and lower frequency changes for specified audio increases from three through 40 dB.

6.1.8 Transmitter Range: Reduce test data into a tabular format indicating the field intensity, the signal-to-noise ratio of the emitted signal from each specified measured test site, M_n, and the environmental conditions. The reduction of environmental data will require conversion of the wet-bulb/dry-bulb measurements into relative humidity readings.

6.1.9 Audio Frequency Response: Reduce test data in a tabular format to show the output voltage level as a function of the input signal level and the resulting percentage of signal distortion.

6.1.10 Dynamic Range: Reduce test data into a tabular format indicating the power input to achieve a standard response for a specified frequency. The output voltage level and percentage distortion will be tabulated as functions of the input power level.

6.1.11 Selectivity: Reduce test data into a tabular format reflecting the bandwidth as a function of the receiver's relative response at a specified frequency. Graphically, test data are shown as the deviations from the resonant frequency for corresponding increases in output.

6.2 Data Presentation.

6.2.1 Power Output: Present power output test data in tabular format in a manner similar to that shown in appendix B, page B-2.

6.2.2 Warm-up Time: Warm-up test data will reflect the elapsed time in minutes and seconds that was required to tune the test item at an ambient temperature and attain maximum transmitter power output. Present data in a tabular format in a manner similar to that shown in appendix B, page B-3.

6.2.3 Channel Selection Time. Channel selection time test data will reflect the elapsed time in minutes and seconds required to move the transmitter from one channel setting to a new setting. Present data in a tabular format in a manner similar to that shown in appendix B, page B-4.

6.2.4 Carrier Noise Level: Carrier noise level test data will reflect the difference in the levels of the detector output levels using a modulated and unmodulated carrier signal. Present data in both a tabular and graphical format in a manner similar to that shown in appendix B, page B-5.

6.2.5 Sidetone Response: Present sidetone response test data in both a tabular and a graphical format in a manner similar to that shown in appendix B, page B-6. In the graphical presentation of the test data, the criteria/specification for the sidetone subtest should be superimposed on the graph of the test item's rated sidetone level.

6.2.6 Modulation Characteristics: Present modulation characteristics test data in both a tabular and a graphical format in a manner similar to that shown in appendix B, page B-7.

6.2.7 Modulator Bandwidth: Modulator bandwidth test data will reflect the difference between the upper and lower sidebands of the carrier frequency. Present data in both a tabular and a graphical format in a manner similar to that shown in appendix B, page B-8.

6.2.8 Transmitter Range: Present transmitter range test data in a tabular format in a manner similar to that shown in appendix B, page B-9.

6.2.9 Audio Frequency Response: Present audio frequency response test data in both a tabular and a graphical format in a manner similar to that shown in appendix B, page B-8.

6.2 10 Dynamic Range: Dynamic range test data will reflect the percentage of signal distortion and the output voltage level as functions of the signal input level. Present data in a tabular format in a manner similar to that shown in appendix B, page B-10.

6.2.11 Selectivity: Present receiver selectivity test data in both a tabular and a graphical format in a manner similar to that shown in appendix B, page B-8. In the graphical presentation of the test data, the criteria/specifications for the selectivity subtest should be superimposed on the selectivity curve plotted for the test receiver.

Recommended changes to this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from Commander, U.S. Army Electronic Proving Ground, ATTN: STEEP-MT-T, Fort Huachuca, AZ 85613. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

CHECKLIST FOR RECEIVER TRANSMITTER SYSTEMS TEST

	INITIALS Test Officer	INITIALS Test Supervisor
Availability of appropriate documentation and authority for the conduct of the test program:	________	________
Initiate a project notebook:	________	________
Establish the project file:	________	________
Availability of appropriate references:		
Required Operational Capability (ROC):	________	________
Test Item Specifications:	________	________
Military Standards:	________	________
Test Operations Procedures:	________	________
Operating Manuals:	________	________
Coordination with test sponsor/ contractor:	________	________
Are dates for desired test execution realistic?	________	________
Availability of test plan to all participants:	________	________
Coordination for necessary test support:	________	________
Identification of critical test issues:	________	________
Test facility conforms to specified standards:	________	________
Brief all test personnel:	________	________
Instrumentation data have been recorded:	________	________
Instrumentation has been currently calibrated:	________	________
Calibration due date for all instrumentation will permit completion of testing:	________	________
Test item data recorded in project notebook:	________	________
Reference level test tapes are on hand:	________	________
Initial inspection performed:	________	________
Photographs taken of test item(s):	________	________
Equipment performance reports prepared:	________	________
Data collection sheets are complete:	________	________
Test report prepared:	________	________

APPENDIX B

DATA COLLECTION SHEETS

DATA SHEET #1

(Power Output Measurements)

FREQUENCY (Hz)	POWER OUT (dBm/W)	AMPLITUDE		PEP (dBm/W)	SAMPLER LOSS (dBm)	ATTENUATOR LOSS (dB)	CABLE LOSS (dB)
		2-TONE WAVE (Volts)	1-TONE WAVE (Volts)				

DATA SHEET #2

(Warm-up Time Measurements)

OPERATION OF THE TEST TRANSMITTER								
OPERATING FREQUENCY: ________ MHz				AMBIENT TEMPERATURE: ________ °C				
TIME TUNING BEGAN AT AMBIENT TEMPERATURE (t_1)			TIME TRANSMITTER ATTAINS MAXIMUM OUTPUT POWER (t_2)			ELAPSED TIME ($t_2 - t_1$)		
HOUR	MIN	SEC	HOUR	MIN	SEC	MIN	SEC	

DATA SHEET #3

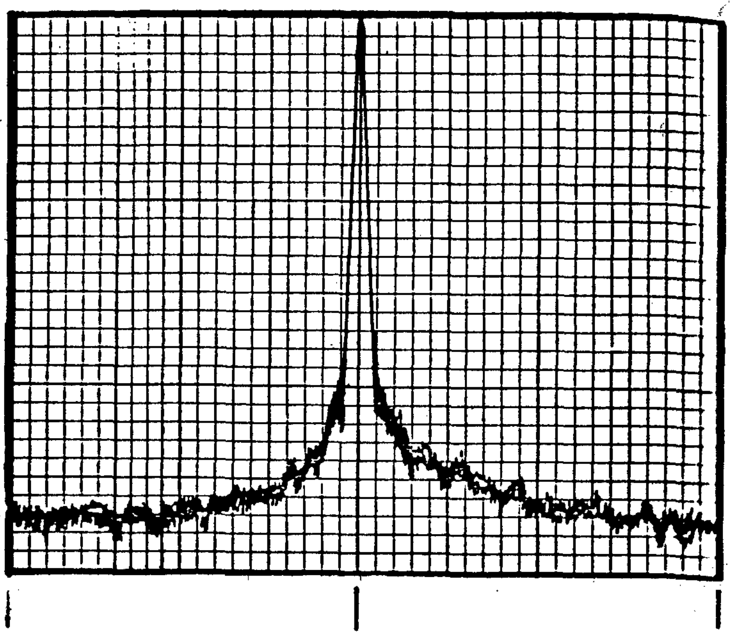
(Channel Selection Time)

OPERATING FREQUENCY		ELAPSED TIME (min-sec)
Initial Frequency Setting (Hz)	New Frequency Setting (Hz)	

DATA SHEET #4

(Carrier Noise Level Measurements)

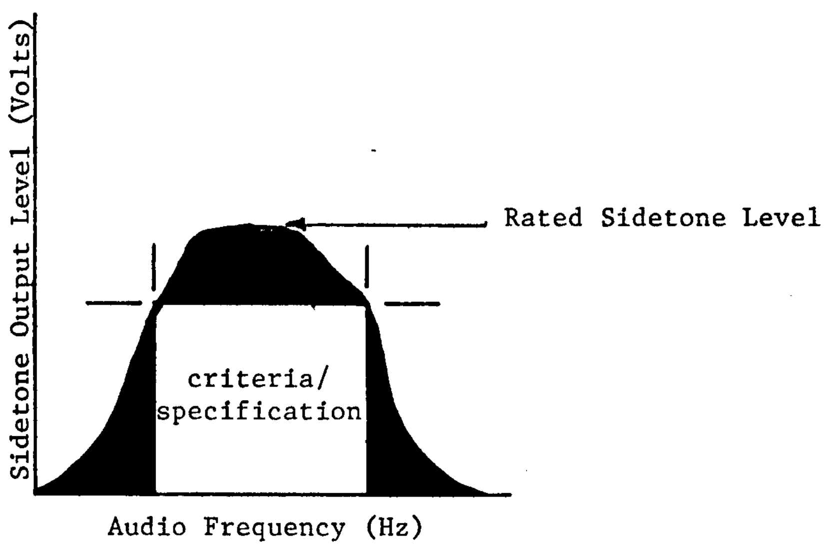
CARRIER FREQUENCY (MHz)	DETECTOR OUTPUT		DIFFERENCE (dB)
	MODULATED CARRIER (dB)	UNMODULATED CARRIER (dB)	



DATA SHEET #5

(Sidetone Response Measurements)

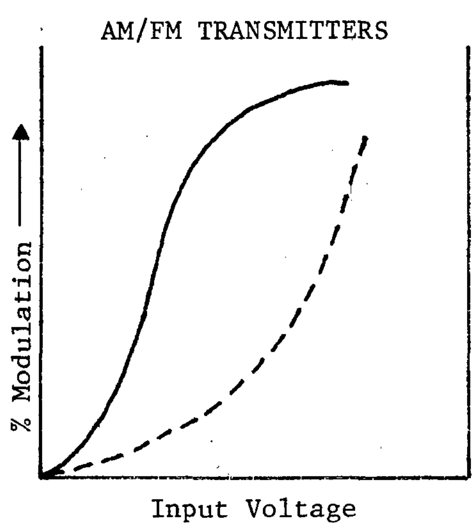
AUDIO FREQUENCY (Hz)	INPUT LEVEL (Volts)	OUTPUT LEVEL (Volts)

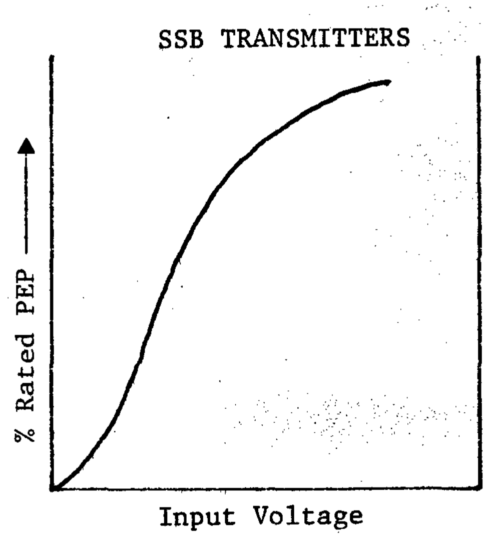


DATA SHEET #6

(Modulation Characteristics)

AUDIO INPUT LEVEL (Volts)	AM/FM TRANSMITTERS		SSB TRANSMITTERS	
	PERCENTAGE MODULATION	PERCENTAGE DISTORTION	PEP (dBm/W)	PERCENTAGE OF RATED PEP

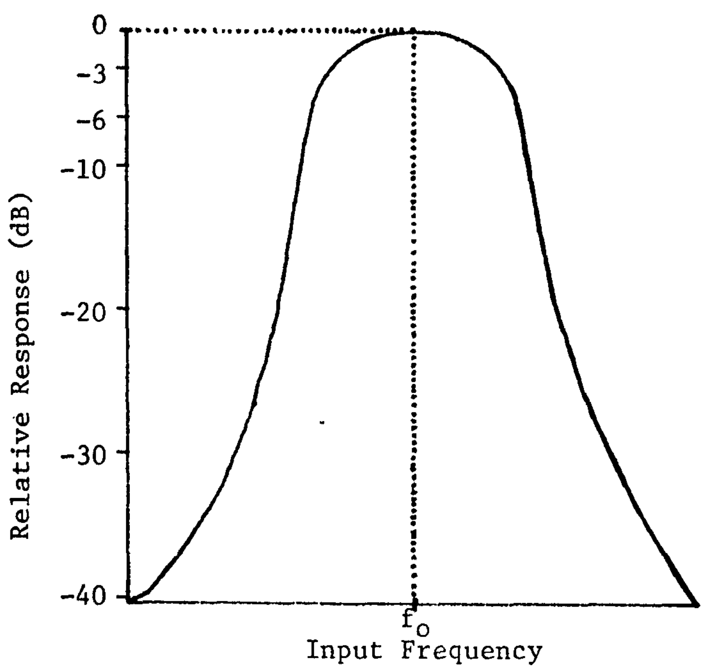




DATA SHEET #7

(For Use in Recording Modulator Bandwidth, Audio Frequency Response, and Receiver Selectivity Measurements)

RELATIVE RESPONSE (dB)	FREQUENCY		BANDWIDTH $(+\Delta F) - (-\Delta F)$
	UPPER $+\Delta F$ (Hz)	LOWER $-\Delta F$ (Hz)	



DATA SHEET #8

(Transmitter Range Measurements)

MEASURED TEST SITE (M_n)	FREQUENCY (MHz)	S/N RATIO (dB)	OUTPUT POWER (dBm/W)	BAROMETRIC PRESSURE (in. of Hg)	TEMPERATURE (°C)	WET-BULB TEMPERATURE (°C)	CLIMATIC CONDITIONS (DESCRIPTIVE)
M_1							
M_2							
M_3							
M_4							
M_5							
M_6							
M_7							
M_n*							

*M_n is a given number of designated measured test sites.

DATA SHEET #9

(Dynamic Range Measurements)

INPUT SIGNAL LEVEL (dB)	OUTPUT VOLTAGE LEVEL (dBm)	SIGNAL DISTORTION (%)

APPENDIX C

STANDARD TEST CONDITIONS

1. GENERAL

a. Certain test conditions apply to the majority of these procedures and therefore can be "standardized." Deviations from these standard conditions occur in specific instances, and these are made clear in the appropriate section.

b. These standard test conditions are recommendations only, and may be modified according to the needs of a particular measurement situation. When this is done, the prevailing test conditions should be recorded with the test data so that proper account can be taken thereof, in the interpretation of the measurement results.

2. AMBIENT CONDITIONS

2.1 STANDARD TEMPERATURE

Standard temperature shall be +20°C to +35°C.

2.2 STANDARD RELATIVE HUMIDITY

Standard relative humidity shall be as follows:

a. Zero to 90 per cent at 20°C to 30°C.

b. Zero to 79 per cent at 30°C to 35°C.

2.3 STANDARD ATMOSPHERIC PRESSURE

Standard atmospheric pressure shall be the ambient atmospheric pressure at the time of the test.

3. PRIMARY INPUT POWER SUPPLY VOLTAGE

Standard input power supply voltage shall be within ±5 per cent of the mean of the rated operating voltage range of the receiver, as given in the manufacturer's specifications.

4. ELECTROMAGNETIC COMPATIBILITY CONDITIONS

These tests shall be conducted, as far as practicable, in areas that are sufficiently free from electromagnetic interference fields to allow the measurements to be made without significant adverse effect on the results. Primary input power sources shall be sufficiently filtered to accomplish the same end. Test instrumentation shall be properly shielded, filtered, and grounded so as to minimize erroneous results caused by extraneous signals from these or other sources.

5. SIGNAL LEVELS

5.1 INPUT SIGNAL VOLTAGE

a. Standard input signal levels are not specified in this procedure. When a specific level is required for a particular test, it is so stated in that test procedure.

b. Radio frequency (rf) input signal levels are expressed in terms of the open circuit voltage across the output terminals of the source of the input signal. When an impedance matching filter or an attenuating network is used between the signal generator output terminals and the test item's input terminals, the input signal level is considered to be the same as the generator output signal level. This is treated as an open circuit voltage measurement.

6. AUDIO OUTPUT POWER

Reference audio output power shall be established for the test item as one of the following power levels:

a. Fifty per cent of manufacturer's rated audio output power.

b. Maximum audio output power having a 12 dB SINAD ratio (6.3 per cent noise and distortion).

c. Manufacturer's rated audio output power.

d. If other levels are used, state the basis for the output power in the report.